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Edinburgh and East of Scotland College of Agriculture

INVESTIGATION INTO "LOUPING-ILL" OR "TREMBLING"

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INTRODUCTION.

THE subject of Louping-ill or Trembling is a very intricate and difficult one, owing to the fact that many different disease conditions are classed together under these terms. Dealing first with the term Louping-ill, I am informed in a letter from Dr Craigie (of the Oxford Dictionary) that it is derived from the Scandinavian word *Hloupa*, to leap, and that thus the term signifies the "Leaping-ill." Indeed, in times past in certain parts of Scotland the disease was actually known as the "Leaping-ill." A clinical entity corresponding to this meaning of the word, and occurring in its purest form among hoggs and older sheep, in reality exists as a cause of great loss among sheep stocks, and is well recognised by shepherds. In this form of disease a sheep, on being given a sudden fright, as by a dog suddenly appearing, may jump in the air, fall down, and after some little kicking expire; or, after having so jumped and fallen down, may lie kicking for a considerable time, and eventually rise up and stagger away. This latter method of procedure may be repeated several times, the animal eventually in some cases possibly dying in one of the seizures. At other times the animal, having fallen down in one of these seizures, fails to get up and remains lying, and is found on examination to be in a more or less paralysed condition. In this condition it may die in a short time, or may remain paralysed for weeks or months, sometimes recovering entirely, but usually exhibiting some residual paralysis. So well known in certain areas of

Scotland is this disease that many shepherds in these districts never send their dog round the sheep without first whistling or making some noise to warn the sheep that the dog is coming.

It is the condition of paralysis just mentioned which has led to an unjustifiable extension of the meaning of the term Louping-ill and to the consequent confusion. Amongst older sheep the term is not so liable to abuse, because among them fewer diseases occur which are liable to be confounded with true Louping-ill;[1] but even amongst such, cases of general weakness simulating paralysis, hydatid of the brain and cord, injury to the legs, tick bites causing lameness, and even foot-rot, have been shown to me as cases of true Louping-ill. In lambs, however, the circumstances are quite otherwise. In their case it is quite unsafe to make the diagnosis of Louping-ill until the animal has been examined post mortem, and an array of other possible causes excluded. The symptom of leaping in the air is very seldom observed in them, and a positive diagnosis on the part of the shepherd rests in some cases mainly on the animal being "down" and unable to get up; in others on true convulsions and on violent attempts to get up, simulating true convulsions; and again in others on paralysis or apparent paralysis of various parts of the body, and even in certain cases on a general unthriftiness. In many localities the misuse of terms has even gone so far that all deaths among lambs from whatever cause are put down as due to Louping-ill. Thus there are included among cases diagnosed by the shepherds as Louping-ill such conditions as navel-ill and its sequels, joint-ill and pyæmia, "milk sickness," conditions caused by tick bites (such as local inflammation due to the tick bite and inflammation of the lymphatic glands draining the area on which the tick bite occurs, both capable of causing lameness, and subsequent pyæmia, with or without joint disease in various situations), "grass sickness," excessive wool-ball in stomach, and injuries of various kinds to the limbs and other parts of the body. This inexact use of terms—quite excusable under the circumstances—has led to great difficulties in the investigation of the disease. Thus, when one is on the spot and actually investigating, it has happened on very many

[1] The variety of disease just described will be referred to as "true Louping-ill."

occasions that prolonged and laborious examinations have been made of cases emphatically diagnosed by the shepherd as true Louping-ill, only to find at the end of the proceeding some simple and quite other explanation of the disease symptoms. Much more important, however, is the fact that it has led to the information obtainable relative to the natural history of the disease being very unreliable, for in any one case an informant, in relating his experience, may be dealing merely with what he considers to be Louping-ill. The condition present may in reality be something quite different.

Again, certain premature theories as to the causation of true Louping-ill have led to further inaccuracies in the information. Thus, for instance, one view, widely spread, is that ticks [1] cause it, and consequently where ticks occur there is a tendency on the part of the shepherd who is imbued with this idea to attribute all deaths among his sheep during April and May to Louping-ill. On the other hand, quite unmistakable cases of true Louping-ill may occur on farms where there are no ticks, yet the shepherd states that he has no Louping-ill in his flock, and justifies his opinion by stating that there are not ticks to cause it.[2] In such circumstances the cases are usually put down as being due to "Stomach Staggers." The result of this state of affairs is that, as a rule, statements made regarding the localities of existence of Louping-ill are quite unreliable. For practical purposes, therefore, one has to take up the attitude that, where information is given

[1] The relation of ticks to Louping-ill will be discussed later, but it may be well to mention here the gist of a conversation which the writer, while investigating the disease in the country, had with a very intelligent farmer relative to its causation. This gentleman stated that Louping-ill, in his private opinion, was *not* caused by the ticks, but as he had been told for a fact by certain lecturers that it was, what could he do but believe them in spite of his better judgment?

[2] The following is an instance of this nature occurring in one of the replies to the circular sent in. "With regard to 'trembling' or 'louping-ill' in this district or in the surrounding parishes, there is no such thing as these diseases here, though shepherds (and many farmers) often refer to cases of 'stomach staggers' as 'trembling.' In this locality I have never seen a tick on a sheep, and I believe a shepherd who has never been employed outside ——shire has never seen one in his life. From here 15 miles due south there are no ticks and no trembling, but across the river there are both." In relation to the matter raised here, I have had personal experience of the last district referred to, having investigated the disease there, and the majority of the cases found, from which it derives its reputation, are cases not of true Louping-ill but of Pseudo Louping-ill due to tick bites, as I shall describe later. The Stomach Staggers or true Louping-ill occurs as well.

regarding Louping-ill among the older ages of sheep even in tick-infested districts, a very considerable amount of credence may be accorded this positive statement. On the other hand, however, a positive statement regarding its occurrence among lambs in tick-infested areas, owing to the numerous simulating diseases caused by the tick, must be received with the greatest caution.

Another minor source of unreliable information is a hesitancy (natural when one considers the circumstances) on the part of certain farmers to acknowledge the fact that they have the disease on their farms. This attitude is taken up in consequence of a belief, wrong or right, on the part of certain sheep-buyers, that the sheep from such farms do not turn out well as an investment.

With regard to the synonymous term "Trembling" used for the disease, much that has been said of Louping-ill can be equally truly said of it. Originally used to designate, from a symptom very observable in it, the disease described above as true Louping-ill, it has come, by processes similar to those resulting in the misuse of the term Louping-ill, to include many other conditions.

Literature on Louping-ill.

The literature bearing on this disease has to be read with the greatest caution, for the causes of unreliability, indicated in these introductory remarks, were equally operative with those who have discussed the matter in print.

Even more so than in the case of Braxy, the articles dealing with the subject of Louping-ill are to be found almost exclusively in the 'Transactions of the Highland and Agricultural Society of Scotland.' Dr Duncan (1) in 1807 discussed the disease under the names of Trembling, Thwarter, or Leaping-ill. He states that these three terms are used as synonymous. At the present time, however, Thwarter-ill, or Thorter-ill, would appear to be restricted to a special disease of sheep caused by a tape-worm cyst settling somewhere in the region of the hind brain. It is only an instance, however, of the lax use of terms inherent in all discussions on this disease. Dr

Duncan himself states that they are applied indiscriminately to all diseases which, on a dry soil, proceed from a debilitated state of body and barren seasons. He discusses the disease under two species. As regards the first species, he states that it is rarer than formerly, and that it is scarcely known in the Highlands. It appears in spring and harvest. Sheep of all ages and kinds are affected, but never when they are in good condition. It exists chiefly on dry farms having a northern exposure, which are evidently overstocked, and on these only when the spring is dry and severe, or when early April grass has been cut down by frosts and the sheep can find no succulent food or any green thing. Its production is favoured by a long continuance of easterly winds, and in cold weather ewes are sometimes attacked by it even after they are fleeced. In these circumstances they become extremely emaciated, especially when many of them are heavy with lamb or giving suck.

He quotes Mr Wm. Hogg, who describes it as of two kinds: in one case seizing the whole system, when there is general trembling over the whole body; and in the other affecting the legs only, when the animal immediately falls down, and the shaking, which is uninterrupted, is confined to the legs. Dr Duncan further refers to a Mr Welsh as stating that the animals which die of the disease in the spring are lean and useless, but that the mutton of fat hoggs carried off by it in September is not uneatable.

Formerly, according to Dr Duncan, it was thought to be contagious; but although he does not believe this, he considers that it is certainly most destructive when it first comes among a flock. When sheep are brought from clean to affected ground, great numbers of them are sure to die. Those which survive one season are almost certain to relapse next spring. To prevent the disease, he recommends the provision during April and May of sufficient shelter and food, avoiding overstocking if the early grass has been blighted, and pasturing them in a rich park, water meadow, moss, or early ryegrass.

The second variety of the disease was described to Dr Duncan by a Mr Stevenson. It appeared to be confined to the flocks in the South of Scotland, more particularly about the banks of the Tweed and its tributaries. It occurs generally during

the summer and harvest months. The animal becomes stupid, neglects its food, dozes round as in sturdy, and frequently leaps in the air. The neck is often stiff and turned to one side; sometimes the sheep are affected with wry necks without exhibiting any of the other symptoms; convulsive spasms are frequently present, sometimes throughout the whole body and involving the jaw, when the animal can no longer eat food. In less severe cases, these spastic attacks abate and the animal recovers the use of its jaws, but its legs are powerless. They eat all the grass round them, sometimes leaving the soil quite bare. If the shepherd lifts them from place to place, provided the season is well advanced, they slowly recover, and the use of their limbs is again restored. It is generally the fattest of the flock that are cut off by it. The disease arises from the Braxy, and is generally a favourable symptom. It is never severe, however, when it is a consequence of Braxy, and the stiff neck never accompanies it.

It might be well, before passing on to consider the next writer on the subject, to discuss some points raised by the description just given by Dr Duncan. It should be noted that the description given here of the disease Louping-ill refers only to hoggs and older sheep. Lambs are not mentioned. Further, that if the disease had not been sharply divided into two species, but if the description of the two species had been blended into one whole, we would have had a very good description of true Louping-ill as we know it at the present day. The reference to fat hoggs dying of the disease in September should be specially noted, as also the definite statement made regarding the origin of the disease from Braxy.

Hogg (the Ettrick Shepherd), 1807 (2), describes the disease under the name Thwarter-ill. He states that it is also called the Thorter-ill, Trembling, and Leaping-ill. He mentions that by these three different appellations shepherds mean to convey the idea of one and the same distemper, though there is every reason to suppose that they have originally been distinct names for three different diseases. Such diseases have all some resemblance in their cause and effects, and attack the flocks at about the same season of the year. The shepherds, therefore, were often unable to distinguish which was which, and by an easy transposition converted them all into one. Hogg has seen

included under these names diseases of sheep such as the following: rheumatism, ague, palsy, apoplexy, and even cases of old sheep dying of weakness and debility. The disease, at that time, was thought by some to be infectious, and it was believed to be as unsafe to buy from a stock infected with Louping-ill as from a stock infected with rot. He mentions as causes of the disease overstocking in seasons when the spring is dry, hard, severe, and frosty. He notes that the disease is peculiar to dry soils, and prevails in dry, barren springs when the wind settles in the east: the sheep are more liable to take it if they are low in body. He refers to a case where the fatigue of udder-locking appeared to bring on the disease. As regards the symptoms, he states that some will fall down and die in two or three minutes; others will lose power of one side and lie sprawling until they die of hunger; others again will lie shivering and very sick at times until death comes to their relief; and some will go a long time quite lame, sometimes carrying one limb and sometimes another, till they are likewise quite exhausted.

Walter Tod (3) discussed the disease in 1832. He considered that foul pasture, produced by overstocking, is the chief cause of the disease. Sheep in low condition of body are especially apt to be affected. A bad summer, a severe winter, and cold weather accompanied with easterly winds in the end of April and beginning of May, are productive of the disease. He considers that the purer and finer breeds are more liable to the disease. He then describes the symptoms of the disease in much the same way as has been done by the writers noted above. He builds up a theory of the causation of the disease, attributing it to a coagulated state of the blood, and to a disturbance of the balance of their circulation. He discusses a common belief that the origin of the disease is in the nature of the soil, and dismisses the idea as untenable. He holds that sudden and violent changes of temperature, and long exposure to the chilly influence of easterly winds, are marked causes of the disease.

Mr Robert Laing (4), in the same volume of the 'Highland and Agricultural Society's Transactions,' also discusses the disease. He states that it is a nervous disease which usually commences suddenly and is accompanied with the loss of sense

or of motion, often of both. In some cases the animal has a strange look, lifts its feet high, is quite regardless of obstacles that occur in its way, and when disturbed runs away in any direction apparently without choice. Some carry the head high like a horse checked by the bridle; others carry it low like a foxhound on the scent; while others have the neck twisted and the head turned to one side, or have one side of the head directed upwards. Sometimes the hind legs are drawn below the body, or are dragged behind as if the animal had its back broken. When a whole side is affected the animal falls and thrusts out its feet; often also it lies on the ground, works with its head and feet, foams a little at the mouth, and shows strong symptoms of convulsions, or stands still, hangs the head, droops the ears, and shows a dull, melancholy look. In some cases the animal is suddenly seized with the disease, falls instantly to the ground, and never rises again. He thinks that dry, barren lands, on which the grass becomes dead earlier in spring and thus allows the stock to get into low condition, are specially liable to the disease. The disease is most prevalent from the 1st to the 25th of May, although it may commence in March and go on till June. If the wind blows from the north or east, accompanied with showers of hail or sleet, the disease is increased. Sheep removed from clean to so-called diseased land are very liable to the disease. He recommends for the prevention of the disease the giving of turnips and sown grass in spring, and the improving of parts of the land to which the sheep can be allowed access during the months of March and April.

Gamgee (5) deals with Louping-ill as contained in a communication made to the Highland and Agricultural Society of Scotland by Mr James Cowan, shepherd, Park, Renfrewshire. Cowan regards the disease as inflammation of the lungs. It makes its appearance during shifting winds, cold showers, or warm days with frost at night. A reduced condition of the animal predisposes to the disease. He mentions that there is often a great mortality among the lambs from the disease. They are often seen playing in groups in the evening, and the next morning several are found dead. [This resembles the variety known as grass sickness.] These lambs are generally from three to five weeks old, and are just beginning to eat a little grass, and, like old sheep, are peculiarly subject to

Louping-ill when there are sudden atmospheric changes, as when the days are warm and the nights frosty, when the wind quickly changes from south or west to east or north-east and there is a rapid lowering of the temperature. He mentions that "Thorter-ill" is often mistaken for Louping-ill, although they are two distinct diseases. He mentions other diseases that are liable to be confounded with it. Thus he speaks of a form of acute indigestion occurring among lambing ewes brought from the hills or travelled a considerable distance and put upon arable land and rich pasture. The affected animals swell, and a green liquid is discharged from the mouth and nostrils. Their staggering gait leads to the supposition that they have Louping-ill. Again, he mentions a disease of sheep peculiar to hill pastures and occurring only in severe seasons that is spoken of as Louping-ill. When heavy and long-continued snows have limited the supply of food, the ewes that are in lamb, especially those bearing twins, become constipated, acquire a staggering and unsteady gait, appear giddy, and if not attended to lose the strength of their limbs, at which stage their recovery is hopeless.

[Possibly this disease may be the same as a disease known in some districts as "Heather-ill," as the symptoms of the two conditions are much the same. It has been said that this "Heather-ill" differs from Louping-ill only in its being less severe and more curable. However that may be, in a case noted this spring of five ewes taken with "Heather-ill," two died in spite of the treatment, and for the present it would seem that there is not sufficient evidence for the view that the two diseases are different in nature.]

Cowan mentions as liable to be confounded with Louping-ill cases of ill-nourished lambs in which there is an effusion of watery fluid around the joints. He mentions also that rheumatism, characterised by swelling of the joints, simulates the disease. The statement is made also that lambs, which have been brought up *partially* on cows' milk, have a tendency to develop swollen joints. This is a view which is widespread at the present day among shepherds.

Gamgee, in criticising Cowan's essay, remarks that Louping-ill, so far as he is aware, is not a simple inflammation of the respiratory organs, but a disease of the nervous system. The only other point to note is that Gamgee translates the French

word *tremblante* as Trembling or Louping-ill. In reality, the word, as used by Gamgee, refers to quite a different disease, namely, the Trotting disease or Scrapie; some of the diseases included under the term *tremblante*, however, may quite well be Louping-ill or Trembling.

Hugh Borthwick (6), 1863, deals with the diseases of sheep fed on turnips. Among such diseases he discusses Louping-ill or Staggers. He states that it generally breaks out among hoggs when put on turnips. He has seldom seen a sheep above eighteen months old attacked with Louping-ill. In acute cases the symptoms are elevation and twisting of the head to one side, glassy appearance of the eye, twitching of the ears, crunching of the teeth and frothing at the mouth. As the disease advances the animal gets quite stupid, rears on its hind legs, and leaps about in a distracted manner. Intervals of freedom from these symptoms are of a few hours' duration. Relapses again occur, and, if not treated, the malady in these cases assumes much the same appearances as distemper in the dog. In cases where the malady is of slow progress, signs of emaciation are visible; a stiffness comes on in the hindquarters, which often become totally paralysed. Sheep sometimes survive in this state for weeks, quite unable to move their hindquarters. Yet they feed as greedily as a healthy sheep. To prevent the disease he recommends keeping the turnips clean, giving a variety of food, and providing shelter at night if the weather is stormy.

Brydon (7), 1859, describes the disease in much the same terms as it has been already described by the writers mentioned above under the name of Louping-ill, stomach or grass staggers. In the same article Professor Dick describes the stomach or grass staggers of horses and cattle. The symptoms are practically identical with those of Louping-ill, and it should be noted that the post-mortem appearances found are extensive inflammation of the stomach in the case of the horses, and intense inflammation, with ulcer formation of the abomasum and large intestines, in the case of cattle.

In the first report (8) of the committee formed by the Highland and Agricultural Society to investigate Louping-ill and Braxy in 1882, the localities of existence of Louping-ill are given, contributions are made to a knowledge of the botany of

some of these districts, and Professor Williams contributes some notes on the pathology of the condition. He states that the disease is confounded with joint-ill or rheumatic and suppurative inflammation of the joints in lambs, with cases of impaction of the fourth stomach with wool-ball, and with navel-ill (with and without implication of the joints). He states, however, that a disease of the nervous system, apart altogether from those just mentioned, really exists, and prevails extensively among lambs and, still more so, among full-grown sheep, occasionally attacking cattle, and said also to attack pigs. He describes the symptoms, which are those of the true Louping-ill mentioned previously. Post mortem, his only finding was a gelatinous exudate surrounding the spinal cord. Professor Hamilton was also involved in these inquiries, as the following quotation shows:—

"The results were not altogether satisfactory. Only one case, a lamb, was obtained, and in Professor Williams' opinion the post-mortem examination only gave negative evidence as to the true nature of the case. As, however, it appeared to Dr Aitken and Dr Hamilton to have all the distinctive appearances of Louping-ill, they made a careful diagnosis of the case. The hind legs were paralysed to some extent, and the pulse was 104° F. The respirations were 30 per minute and somewhat irregular. Having the means of testing the germ theory all provided, the animal was killed and cultivations were attempted with the blood, aqueous humour, and cerebro-spinal fluid. After twelve hours in the warm chamber the blood and aqueous humour remained inactive, but the cerebro-spinal fluid was found to be cultivating vigorously. Specimens were taken of the germs, and drawings made of the culture. They resembled closely the germs found in chicken cholera." This culture was lost through accidental overheating. It is interesting, however, to note this finding of an organism resembling the organism of chicken cholera in a case of apparently true Louping-ill. No further investigations in this direction appear, however, to have been carried out. In this report the tick is first suggested as a possible cause of the disease.

Professor Williams (9) in the following year made a further report on Louping-ill, which he now designated by the name of *Chorea paralytica ovis*. In some of the cases observed by him

he had found the jelly-like exudate in the spinal canal which had been described by him previously. This, however, was the only positive post-mortem finding obtained in his cases. The various possible causes of the disease are discussed. The disease appeared to be present on soils of very different natures, on various geological formations, and at very different altitudes. Mr Brotherston put forward the view that it was due to micro-fungi existing on old withered grasses. These fungi acted on the body like ergot. An experiment, however, was performed which satisfied him that this was not the case. As regards the effect of the weather, it was noticed that a change from warm to cold inclement weather markedly increased the mortality. The weather conditions, however, were regarded as secondary, predisposing to the disease by debilitating the animal. Professor Williams finally comes to the conclusion that the tick is the cause of the disease, and that it effects this by means of a bacillus, which he professed to find in the jelly-like material of the spinal cord and in growths made from the tick. It is sufficient to say here that, with regard to his finding of this specific causal bacillus, there is no cogent evidence. In a further paper Professor Williams (10) again discusses the disease under the name Ixodic Toxæmia. He reaffirms his views regarding its ætiology and pathology, and expresses the conviction, based on further observations, that where there are no ticks there is no Louping-ill.

The report of the Departmental Committee, appointed by the Board of Agriculture to investigate Louping-ill and Braxy, was published in 1906. I have already (11) shown that the organisms, stated by this committee to be causal of Braxy, are of the nature of putrefactive organisms, and the same remark applies to the organism—the *Bacillus Chorea paralytica ovis*, Hamilton—which they state to be causal of Louping-ill. With regard to the relation of the tick to the production of the disease, elaborate experiments were undertaken to test the possibility. The conclusion is that the evidence is against it. The simple and conclusive natural experiment of finding Louping-ill cases on land where ticks had never been known to exist on the sheep, such as on low-ground arable farms, was not, however, considered by the committee.

The *résumé* just given of the literature on the disease has

dealt entirely with it as it exists in Scotland. Probably the disease exists wherever sheep are kept, and possibly records of its occurrence exist.[1] Owing, however, to the variety of symptoms exhibited in the disease, and to a selective emphasisation of one symptom and a consequent naming of the disease from that symptom, it is impossible to institute comparisons with anything approaching accuracy. The diseases known in England as twitch, trembles, moss illness, dizzy, turn in the head, &c., are possibly identical with Louping-ill; while descriptions of diseases more or less resembling it occur in the French and German text-books. The known confusion of the subject, and the multiplicity of different diseases included under the term in Scotland, make one hesitate, however, to go further than merely mention these facts.

Symptomatology and Pathology.

It would appear that true Louping-ill is divisible into several more or less distinct clinical varieties. These varieties are not, however, sharply defined, but shade off into one another. But, from certain predominant characteristics, it is more or less possible to parcel out, in a rough way, the different varieties.

Variety 1.

This is the very mild form, the animal usually returning to health again without the disease progressing further. On

[1] With regard to this point I have a note from Mr James Greenshields, Gaiman, Chubut, Argentine Republic, regarding the occurrence of the disease in Patagonia. It is known in Spanish as "Chuchu," and in English as "Staggers" or "Shakes." The trouble is observed chiefly in the dry season, namely March, April, and May, when there is great heat during the day and cold frosts at night. The sheep affected are chiefly lambs of from six to eight months old. The lambs are apparently in quite good health, but when subjected to a sudden fright, as by a dog suddenly appearing, they jump into the air, run a few yards, then stagger, fall down, and become paralysed. The eyes become more prominent and are in a state of glare. They will usually be in this state for a few days before expiring or recovering. Very often when removed to a new pasture they rapidly recover and become quite lively.

For some years past the disease has been observed only in lambs, but of recent years older sheep have been noticed with it, and all over the disease has been observed to be on the increase. The district where the disease occurs is situated in a tract of land called Chubut, stretching from the coast of Patagonia up to fifty miles inland. The land is not mountainous, but consists of hills and valleys producing a good quality of grass.

the other hand, it may constitute the prodromal stage to other and more severe forms. It is seen in its typical form among the older sheep, especially in hoggs, and, among them, specially well when they have returned from their wintering to the hill pastures. When marked cases of Braxy and Louping-ill are occurring among such hoggs, it is noticed that a large number of them are affected with what the shepherds call "a touch of Louping-ill." Such animals do not wander far from one spot, and lag behind the others when the flock is put in motion. They continue to feed, but they are dull and heavy. Little else is seen wrong with them, and the majority of such cases recover after a short time. On the other hand, some of them may develop more marked symptoms of the disease and eventually pass through the stages to be described in some of the other varieties. When a shepherd notices such a case his policy is to leave it entirely alone. He never goes near it himself, nor does he allow his dog to approach it. For this and several other reasons no opportunity arose for examining these cases more closely.

Variety 2.

Is a more advanced stage of variety 1. In variety 1, it was noticed that there was "something wrong" with the animal. In this case, definite morbid symptoms are present. The animal is dull, off its feed, does not wander abroad, and is slow in its movements. On very slight exertion it becomes breathless and trembles all over. After a short run it will sometimes lie down, even although shepherd and dog are within a few yards of it. Its gait, in running, is staggery. The temperature is raised, and there is usually constipation. There may be a slight discharge from the nose. The following cases illustrate this variety, as also variety 1.

About the beginning of May a lot of blackfaced hoggs were taken to a hill farm. After being kept on the low fields for some time, they were sent out to the hill. A week and a half after they were put to the hill, Louping-ill began amongst them. They were at once brought down to the low ground. They were seen by me on May 2, and, out of about a hundred, approximately a dozen were in the variety 1 stage—*i.e.*, they

were dull, heavy-looking, inactive, lying down more than they should, and evidently "something" the matter with them. Two others were much worse. They were very dull and heavy, appetite gone, and lying in one place. On being approached, although they took notice, they made no effort to get out of the way. They were caught with very little difficulty, but even the slight exertion made by them to avoid capture caused them to tremble all over and even to sink down to the ground. There was no diarrhœa; the rectal temperature was 42° C. There was a serous discharge from the nose in both cases. On being released, both animals ran a few yards and lay down panting for breath. On May 3, these two cases were again observed. They were lying down, and one of them was chewing its cud. On being approached to within 100 yards, both got up and walked away, but almost immediately lay down again. There was no lameness, and they were quite alert. These two hoggs were afterwards kept in a field by themselves; no one went nearer them than the fence, and on May 20 it was noted that they were quite well again. The marked feature in this variety is the capacity for being easily tired on very slight exertion, evidenced by the trembling, the panting for breath, and the tendency to lie down. As yet, however, there is no evidence of paralysis, no loss of mental alertness, and no fits. Such cases, however, may instead of recovering go on to a condition of paralysis of one or more limbs, as will be noted later, or they may develop into the next variety to be discussed.

Variety 3.

This variety is known in certain districts of Scotland as the "Lóuping-ill sickness." By this is meant that such cases have all the symptoms of Louping-ill during life, but post mortem the appearances are those usually found in sickness or Braxy.

The symptoms exhibited in such cases are an aggravation of those present in the two varieties just discussed. The dullness and apathy is intensified, the animal remains in one spot, it ceases to feed, rumination is stopped, and the temperature is raised; it trembles all over, its gait is staggery, and if caused to go through a narrow opening it may stumble against

the sides of it; if caused to run in the open, it may go a short distance and then tumble heels-over-head (does not quietly lie down as in last case) and lie with its eyes fixed and insensitive. There has been failure of the heart, which may end in death of the animal almost immediately; or the animal, after lying down for some time, may recover somewhat and get up again. In other cases there is definite evidence of involvement of the brain and spinal cord. The animal has a wild look, and behaves in a mad fashion, rushing wildly against obstacles, apparently without seeing them. Sometimes a horn is broken off, or the animal damaged in other ways. Paralysis of various kinds, spastic and flaccid, may be present. Champing of the jaws, frothing at the mouth, irregular nodding of the head, are often seen; rolling of the eyes occurs, and sometimes there is an ocular squint. The fate of animals affected with this variety of the disease is sometimes that, on experiencing a sudden fright, they may jump in the air and fall down dead; on the other hand, after having fallen down, they may get up again and repeat this process several times. Eventually in most cases they tumble down and are unable to get up again. Very few of these cases get better. After lying about for a few days in a more or less paralysed condition, most of them eventually succumb. A few which recover retain traces of the disease in the form of a twisted neck, lame leg, &c. Often, in this variety, there is evidence of some diarrhœa. Post mortem the appearances are those found in braxy carcases, namely, hæmorrhages in the muscles of the body, especially in those of the thorax, marked hæmorrhages in the heart muscle, subepicardially and endocardially; marked amber-coloured effusion, often with coagula and often blood-stained, into the pericardium; sometimes effusion, amber- or blood-stained, into the pleural sacs; usually œdema and congestion of the lungs; sometimes, however, acute congestion and commencing pneumonia are present; gelatinous infiltration, with hæmorrhages, in the mediastinum; œdema, and congestion, with hæmorrhages, of the thoracic lymphatic glands. In the abdomen, in a number of cases, amber-coloured or blood-stained effusion, sometimes in large quantity, into the peritoneum; subperitoneal petechial hæmorrhages; submucosal

hæmorrhages in the fourth stomach and small intestines, and often marked inflammation in both these situations. There are often very marked congestion and hæmorrhages into the cortex of the kidney. This, along with commencing putrefactive changes, is the cause of the diffluent state of the kidneys often found in these cases. The mesenteric and abdominal lymphatic glands are often enlarged, congested, and hæmorrhagic. The so-called braxy smell is present in cases which have lain a little after death. Hæmorrhages are sometimes observed in the central nervous system. A particular form of this variety occurs in ewes on lambing, and symptoms usually appear on the day of parturition, and gradually take on the nature just described. Death usually occurs after two or three days, when the post-mortem appearances are those just described.

Variety 4.

This variety includes Braxy and "grass sickness." The symptoms of these have been discussed elsewhere (11), and there is no need to repeat them here. It is sufficient for the purpose in hand to state that the outstanding feature of the symptomatology of these diseases is that the animal is rarely seen in a sick condition while alive, and is usually first noticed when dead. The post-mortem appearances are those just described for variety 3. Death from Louping-ill often occurs from the animal getting a sudden fright, and the possibility of such an occurrence, in cases regarded as having died from Braxy, must be considered. This point, however, need not be further discussed, for whether an animal has died of Louping-ill (variety 3), or of Braxy or "grass sickness," the post-mortem appearances are exactly the same in all three cases, and further, the causal organism is the same. The only difference, and an unimportant one from the point of view of the ætiological identity of the two diseases, is that one exhibits nervous symptoms, and the other, so far as the accepted definition of the term goes, does not.

The next two varieties to be discussed are those exhibiting definite paralysis of some part of the body. In variety 3 such

paralyses are more or less obscured by the occurrence of head symptoms and convulsive attacks. In these two varieties a definite paralysis exists without any such concomitants.

Variety 5.

In this variety, along with high fever and other evidence of an acute and severe illness, the animal retains its intelligence, there is an absence of cramps or convulsions, but there is definite evidence of a more or less extensive paralysis, together with evidence of involvement of the lungs. The following is an instance of such a case.

A half-bred gimmer, about the 14th February, was noticed to be constantly bleating whenever the shepherd appeared. This had never occurred before with her. Three days after that she became definitely ill. There was a discharge from her nose, froth at the mouth, and when the animal was lying down its head kept shaking. The animal could still walk. It continued to eat its food. On the 20th, however, it became worse; it ceased to eat, and became paralysed in its hindquarters. The animal remained quiet, docile, easily handled, and intelligent. It died on the 23rd. At the post mortem the lesions of hæmorrhagic septicæmia were found, more marked, however, in this case in the lungs, which were practically like blood-clot, owing to massive hæmorrhages. The organism of hæmorrhagic septicæmia was obtained in pure culture from them. This case illustrates how the symptoms of an animal infected with the organism of hæmorrhagic septicæmia may vary with the site of the lesion. It also shows that infection with this organism is associated with paralysis. This variety is especially frequent among bought-in tups in September. In these animals, too, another symptom is observed, namely, great swelling of the scrotum. This is due to œdema, and is referable to the weak condition of the heart. Such rams are useless for breeding that season, but if they recover are quite fit for service next season.

Variety 6.

In this variety is included what one may term the paralytic sequelæ of the disease. An animal, after having exhibited the symptoms of varieties 1 and 2, develops paralysis more

or less profound. The following is an illustration of this variety. On 23rd April a hogg was observed which was diagnosed by the shepherd as suffering from typical Louping-ill of a mild variety. It had been noticed ailing for a fortnight. It wandered away by itself, was dull, restless, without any "life," head hanging, and went down hill rather than up. On being approached on the 23rd, it looked up heavy-eyed, dull, and walked away as if it could not help it, and began insensibly to go down hill. After it had gone about 200 yards it fell to the ground, staggered up again, and began to rush blindly and precipitately down the hill. After going about 30 yards (its weight more than anything else and an attempt to maintain its balance had carried it down the hill), it managed to draw up, where it stood shaking, listless, and dull. This condition, with slight improvement, continued till about May 6. On this date the animal was found down and unable to rise. It was very thin; there was no diarrhœa, no discharge from nostrils, no cough. The temperature was slightly below normal. The animal was killed by bleeding, and, post mortem, beyond extreme emaciation, the only lesions found were a few old resolving hæmorrhages on the auricles of the heart, a very dried sodden mass of vegetable matter, &c., like a half-dried peat, filling the rumen, and hard angular fæces covered with mucus and blood in the rectum, which part of the intestine was spotted with minute traumatic hæmorrhages, caused by the hard angles of the fæcal pellets. The resolving hæmorrhages on the heart were the only evidence of the previous condition. The dried state of the material in the rumen and of the fæces was in all probability due to the animal, in its paralysed condition, being unable to get to water or succulent herbage.

I have examined a very large number of cases of this sort, and, in all, the findings have been practically the same as those just described. One point should be specially noted—there is no rise of temperature, rather the opposite. The dried content of the rumen and the hardened fæces, covered with mucus and blood, are almost always present. The animals are very emaciated. Their appetite is almost always good, and if frequently dragged to fresh pieces of grass they will live for a long time. Some of them even recover, usually, however, retaining a small amount of residual paralysis,—it may be weak

hindquarters, giving rise to the seal-like gait, the "swey" or "swivel" back, lameness in a leg, or twisting of the neck.

As regards the lesions found in the spinal cord in such cases, these often do not appear till the animal has been paralysed for some time. They have been described elsewhere (12), and need not be gone into fully here. Briefly, they consist of small-celled infiltration, especially round the vessels, chromatolysis, neuronophagia, and disappearance of the nerve cells in the anterior horn of grey matter in the cord. Where the paralysis has lasted only a short time nothing abnormal may, however, be seen.

A special point to be noted in connection with this variety is, that the cases are in the majority of instances first seen to be ill when they are "down." They have passed through the acute stage of the disease, probably variety 1, unnoticed, and it is only when the dregs appear in the form of paralysis that they are noticed.

Variety 7.

The disease known as "milk sickness" would appear to be of the same nature, ætiologically and pathologically, as Louping-ill and Braxy. This disease affects lambs, usually about the second or third day after birth. Generally the condition is put down to the ewe having too rich milk. In most cases it is characterised by a white pultaceous diarrhœa, but, in some cases, this diarrhœa is dark and blood-stained. The lambs usually die from the fifth to the tenth day of the disease. Post mortem, one finds the characteristic pericardial effusion and hæmorrhages in the heart, the œdema of the mediastinum and lungs, the enlargement and hæmorrhagic congestion of the lymphatic glands, and œdema and hæmorrhages in the thymus, all of which one finds so markedly in Braxy. In the abdomen one finds congestion and hæmorrhages in the fourth stomach and especially in the small intestine. The blood in the stools may come from the hæmorrhages in the intestine; but, on occasions, also from an acute intussusception, with strangulation of the bowel, which I have noticed in one or two cases. This intussusception is predisposed to by the irritation in the bowels. The organism of hæmorrhagic septicæmia was obtained from the blood and intestines of these cases.

Comparison of Louping-ill with other Disease Conditions resembling it.

Perusal of the literature on sheep diseases in this and other countries negatives the existence of any disease of a similar nature in sheep being recorded with which the disease just described could be justly compared. Either clinical symptoms are given without any bacteriological evidence as to their causation, or, on the other hand, bacteriological entities are described with symptoms which might or might not be the same as those in true Louping-ill. It must be left for other workers to say whether there exists in their countries a disease bacteriologically, pathologically, and clinically the same as that just described. It must, however, be mentioned that in many places in Scotland, among shepherds and others, the terms "Stomach Staggers" and "Staggers," with reference to sheep, are used as identical with true Louping-ill. This occurs chiefly where the individuals using the terms have had experience of land without ticks and land with them. On the other hand, where the view is held that ticks cause Louping-ill, and where at the same time no ticks exist on the sheep, cases of "Staggers" are differentiated from Louping-ill, for the individuals in question argue that as there are no ticks on the land the disease cannot be Louping-ill. It may be said, however, in connection with this question, that the symptoms of Staggers are exactly those of true Louping-ill, and that the two diseases are identical. The text-book description of the symptomatology is the same, and post mortem among the findings described for "Staggers" are acute hæmorrhagic inflammation of the fourth stomach and of the small intestines. This subject will be returned to in dealing with the supposed relationship of the tick to the disease. Meantime the subject of the occurrence of true Louping-ill in animals other than the sheep will be considered with the view to throwing light on the question. Everywhere, all over uplands of Scotland, the view is held that cattle take the disease and are affected in every way in the same manner as sheep. The disease is indeed called "Louping-ill" or "Staggers." It occurs at the same time of the year and under the same conditions—exposure on the hills

in spring during dry, barren weather, with a hard east wind. Personally I have seen the following cases of the kind. A batch of yearling queys, which had been house wintered, were sent about the middle of May to the hill. Shortly after being sent, several of them began to be taken ill with symptoms which were described by the shepherd as those of Louping-ill or Staggers. One of the milder cases was seen by me, as it had been brought into the byre. It had been taken ill two days before. It staggered a good deal, its temperature was raised, and it was with difficulty got to the byre. It was dosed with treacle, &c., and when it was seen two days after it had been first noticed ill, the animal was considerably recovered. It was now walking fairly well, and its temperature was 100·2° F. Another of the same batch, however, was much more severely affected. It suffered from violent nervous symptoms, convulsions, and tremblings. Its temperature was 104-106° F. It was dosed, by the veterinary surgeon in attendance, with chloral and bromide. It died two days after it was first noticed ill. The post mortem showed numerous hæmorrhages in the muscles of the body, especially in those of the side of the thorax. In the thorax there was œdema of the lung, with effusion into the pleural sacs; effusion into the pericardium, with very marked hæmorrhages into the heart; and œdema and hæmorrhages in the mediastinum. There were also inflammatory changes with hæmorrhages in the fourth stomach; and the kidneys were markedly congested and hæmorrhagic. The organism of hæmorrhagic septicæmia was obtained from this case. An exactly similar case, this time on a lowland arable farm, was also seen by me, while I have given a record elsewhere (*loc. cit.*) of several cases which occurred during the month of September. Spreull (13) describes the disease as it occurs in South Africa under the name of "Lamziekte." This name, he states, is descriptive enough as far as the paralytic form is concerned. It does not, however, aptly fit the throat form, nor even the very acute lung and bowel forms, in which paralysis appears only when the animal is *in extremis*. According to its type, he mentions, it is also called "blood-lung," "imapunga," "veld-sickness," "gall-sickness," and "heart-water." He states that he has found it chiefly in cattle and goats. It attacks all ages, even calves of nine days old. The

paralytic form is the chief variety seen inland, while the other two varieties described occur more on the coast. He describes an œdematous or throat form, with swollen tongue, neck, and head, with great difficulty in breathing, fever, rapid wasting, and diarrhœa. A thoracic form also occurs where the lungs are acutely congested, with also the occurrence of early red hepatization and abomasal and bowel lesions, often as marked as in the paralytic form. Paralysis appears when the animal is *in extremis*. In the paralytic variety, the first thing noticed is often a cessation or diminution of the milk supply. The temperature, pulse, respirations, and excretions may, however, be quite normal, and no further sign of disease may be noticeable until the stiffness of gait comes on. He has seen acute cases, with rapidly developing stiffness and inability to walk more than a few yards without lying down, show practically no sign of discomfort. The acute cases are all fatal, and the earlier they go down the shorter time do they live. In the peracute cases, which die in from twenty-four hours to three days, the onset of symptoms is very rapid. These are stiffness, loss of appetite, cessation of rumination, depression of temperature, grinding of the teeth, stupor, salivation, frequent eructations and swallowing movements, and paralysis, manifested by the animal going down within a few hours and refusing to rise again. The chronic form lasts a long time, and the recoveries are frequent. Some dreg, however, is usually left in the shape of paresis of muscles, limbs, or quarters.

The post-mortem findings in the paralytic form he describes as follows:—

Sometimes there is congestion of the lungs, effusion into the pleural sacs, œdema of the mediastinum, enlargement, œdema, and hæmorrhagic inflammation of the thoracic lymphatic glands, and minute hæmorrhages into the thymus. There are petechial hæmorrhages, subepicardially and subendocardially, in the heart, while there is also an effusion into the pericardium. There is also an amber-coloured exudate into the peritoneal cavity. He notes that, while in many cases which have always had plenty of water supplied to them during the illness, and generally a purgative drench given at the outset, there has been no impaction of the stomach, he can hardly believe that such a lesion is common in this disease; but he inclines to

think that where present it is due to the cattle having "gone down" far from water, and died without being supplied with it.

He states that the abomasum is almost invariably inflamed, sometimes very severely. Its mucous membrane is swollen, and shows erosions and early ulcerations. The small bowels are more or less inflamed. There are hæmorrhages into them, with blood in the fæces. The cæcum, colon, and rectum are only slightly inflamed. The lymphatic glands in the abdomen are swollen, inflamed, and hæmorrhagic. The spleen is normal. The kidneys are congested with hæmorrhages in the cortex. The mucus membrane of the nose is inflamed and congested. The cause of the disease in all these various forms is, according to Spreull, an organism of the hæmorrhagic septicæmia group. The resemblance of the œdematous form, especially if we consider that the name "gall-sickness" is sometimes applied to it, to "head grit" or "yellowses," a disease which I have elsewhere (11) hinted is due to a hæmorrhagic septicæmia organism, is striking; while the lung, bowel, and paralytic forms are the exact counterpart of varieties 3, 5, and 6 of Louping-ill described above.[1]

Bacteriology.

The view enunciated here is that true Louping-ill in its various varieties is caused by *B. bipolaris septicus ovium*, and some points now fall to be considered in connection with the bacteriology of the disease. In conjunction with Dr Wang (14), I have shown that an avirulent culture of chicken cholera, which fermented only a few sugars, and these with acid formation only, by the process of *passage* through animals to make it more virulent, took on a much greater fermentative power, now fermenting many more sugars, and all with acid and gas production. At the same time, the colonies of the virulent organism on surface agar were much bigger, and

[1] It may be mentioned that I am at present preparing a report on an extensive development of paralysis in fowls following on an attack of chicken cholera, a disease due to another member of the hæmorrhagic septicæmia group. It should also be noted that paralysis is a common occurrence in swine fever and pink-eye of horses, both of which diseases have a close association with a member of the hæmorrhagic septicæmia group of organisms.

[ABLE I.

	32.	37 A	60 A.	60 B.	B. Coli, newly isolated from human faeces, two strains from different colonies.	
Source ill.	Lamb. Dead. White scour. Lung.	Lam Kille White s Intest	Ewe. Killed. ouping-ill. Lung.	Ewe. Killed. Louping-ill. Lung.		
Nature of inal cult	pure	6 colo 37 A, unifo growth	ixture of 60 A and 60 B	mixture of 60 A and 60 B	...	...
Agar . .	good growth	goo grow	good growth	good growth	good growth	good growth
Inuline .	O	O	O	O	O	O
Adonite .	O	O	O	O	O	O
Cane . .	O	O	A+G	O	O	O
Raffinose	A+G	O	O	O	A+G	A+G
Salicine .	O	O	A+G	A+G	O	O
Mannite .	A+G	A+	A+G	A+G	A+G	A+G
Galactose	A+G	A+	A+G	A+G	A+G	A+G
Dextrine	A+G	A+	A+G	A+G	A+G	A+G
Maltose .	A+G	A+	A+G	A+G	A+G	A+G
Lactose .	A+G	A+	A+G	A+G	A+G	A+G
Sorbite .	A+G	A+	A+G	A+G	A+G	A+G
Dulcite .	O	A+	A+G	A+G	A+G	A+G
Glucose .	A+G	A+	A+G	A+G	A+G	A+G
Litmus mi	A+C	A+	A+C	A+C	Acid	Acid
Peptone . ol	marked Indol	mark Ind	marked Indol	marked Indol	marked Indol	marked Indol
Nitrate W s	marked nitrites	mark nitri	marked nitrites	marked nitrites	marked nitrites	marked nitrites
Gelatine . f.	no liquef.	no liq	o liquef.	no liquef.	no liquef.	no liquef.
Reaction ied bit afte travenou jection	not tested	dead one h	ot tested	not tested	...	...
Motility .	none	?	none	none	feebly	feebly
Gram .	neg.	neg	neg.	neg.	neg.	neg.
Morpholog st	as in last	as in l	s in last	as in last	uniform bacilli?	uniform bacilli?

ion. C=
he culture was obtaine

a large dose and as described in text.

TABLE I.

	22.	38.	20.	36.	44.	9.	1.	33.	6.	31.	48.	18.	3.	32.	37 A.	37 B.	13.	43.	5.	25.	59.	11.	16.	30.	60 A.	60 B.	B. Coli, newly isolated from human feces, two strains from different colonies.	
Source.	Ewe. — Killed. Louping-ill. Intestine.	Lamb. — Dead. White scour. Intestine.	Lamb. — Dead. Grass sickness. Lung.	Lamb. — Dead. Grass sickness. Intestine.	Lamb. — Killed. White scour. Intestine.	Lamb. — Dead. Grass sickness. Lung.	Lamb. — Killed. White scour. Intestine.	Lamb. — Dead. Grass sickness. Lung.	Lamb. — Killed. White scour. Lung.	Lamb. — Dead. White scour. Intestine.	Ewe. — Killed. Louping-ill. Intestine.	Hogg. — Killed. Louping-ill. Lung.	Ewe. — Killed. Louping-ill. Lung.	Lamb. — Dead. White scour. Lung.	Lamb. — Killed. White scour. Intestine.	Lamb. — Killed. White scour. Intestine.	Ewe. — Killed. Louping-ill. Lung.	Lamb. — Dead. White scour. Intestine.	Lamb. — Dead. Grass sickness. Lung.	Lamb. — Killed. White scour. Intestine.	Lamb. — Killed. White scour. Intestine.	Lamb. — Killed. White scour. Intestine.	Lamb. — Dead. White scour. Lung.	Ewe. — Dead. Louping-ill. Intestine.	Ewe. — Killed. Louping-ill. Lung.	Ewe. — Killed. Louping-ill. Lung.	...	...
Nature of original culture	pure	pure	pure	pure	pure	pure	pure	pure	pure	pure	pure	pure	pure	pure	6 colonies 37 A, rest uniform growth 37 B	37 A and 37 B	pure	pure	pure	pure	pure	pure	pure	pure	mixture of 60 A and 60 B	mixture of 60 A and 60 B	...	...
Agar	good growth O	good growth O	good growth O	slight growth O	good growth O	good growth O	good growth O	good growth O	good growth O	good growth O	good growth O	good growth A	slight growth A	good growth O	good growth O	good growth O	good growth O	good growth O	good growth O	good growth O	slight growth A	good growth O	good growth O	good growth O	good growth O	good growth O	good growth O	good growth O
Inuline	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Adonite	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O	O
Cane	A	?	A+G	A	O	A	A+G	O	A	A+G	O	O	O	O	O	?	A+G	A+G	O	O	A	O	O	O	A+G	O	O	O
Raffinose	A+G	A?	A+G	A	A+G	A	A+G	O	A+G	A+G	O	A	O	A+G	O	O	A+G	A+G	A+G	O	A	A+G	A+G	A	O	O	A+G	A+G
Salicine	O	O	A+G	O	A+G	O	O	O	A+G	O	A+G	O	O	O	O	O	A+G	A	A+G	A+G	A	O	A+G	A+G	A+G	A+G	O	O
Mannite	A+G	A+G	A+G	O	A+G	O	A+G	O	A+G	A+G	A+G	A?	O	A+G	A+G	A	A+G	A+G	A+G	A+G	A	A+G	A+G	A+G	A+G	A+G	A+G	A+G
Galactose	A+G	A+G	A+G	A	A+G	A	A+G	O	A+G	A+G	A+G	O	O	A+G	A+G	A	A+G	A+G	A+G	A+G	A	A+G	A+G	A+G	A+G	A+G	A+G	A+G
Dextrine	A+G	A+G	A+G	A	A+G	A	A+G	O	A+G	A+G	A+G	A?	A	A+G	A+G	A	A+G	A+G	A+G	A+G	A	A+G	A+G	A+G	A+G	A+G	A+G	A+G
Maltose	A+G	A+G	A+G	?	A+G	A	A+G	O	A+G	A+G	A+G	O	A	A+G	A+G	A	A+G	A+G	A+G	A+G	O	A+G	A+G	A+G	A+G	A+G	A+G	A+G
Lactose	A+G	A+G	A+G	A	A+G	A	A+G	O	A+G	A+G	A+G	O	A	A+G	A+G	? A	A+G	A+G	A+G	A+G	O	A+G	A+G	A+G	A+G	A+G	A+G	A+G
Sorbite	A+G	A+G	A+G	O	A+G	O	A+G	O	A+G	A+G	A+G	O	O	A+G	A+G	O	A+G	A+G	A+G	A+G	O	A+G	A+G	A+G	A+G	A+G	A+G	A+G
Dulcite	A+G	A+G	A+G	O	A+G	O	A+G	O	A+G	A+G	A+G	O	O	O	A+G	O	A+G	O	A+G	A+G	O	O	A+G	A+G	A+G	A+G	A+G	A+G
Glucose	A+G	A+G	A+G	O	A+G	A	A+G	O	A+G	A+G	A+G	A	O	A+G	A+G	A	A+G	A+G	A+G	A+G	A	A+G	A+G	A+G	A+G	A+G	A+G	A+G
Litmus milk	A+C	A+C	A+C	A+C	A+C	A+C	A+C	O	A+C	A+C	A+C	A+C	A+C	A+C	A+C	A	A+C	A+C	A+C	A+C	A+C	A+C	A+C	A+C	A+C	A+C	Acid	Acid
Peptone	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites	no Indol Trace	marked Indol marked nitrites	no Indol Trace	marked Indol marked nitrites	no Indol no nitrites	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites	no Indol Trace nitrites	no Indol Trace nitrites	marked Indol marked nitrites	marked Indol marked nitrites	no Indol Trace nitrites	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites	no Indol Trace nitrites	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites	marked Indol marked nitrites
Nitrate W.																												
Gelatine	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.	no liquef.
Reaction in rabbit after intravenous injection	not tested	not tested	not tested	not tested	typical	...	not tested	not tested	typical	typical	typical	not tested	not tested	not tested	dead in one hour	typical	typical	typical	not tested	typical	not tested	died in one hour	typical	not tested	not tested	not tested	...	...
Motility	?	?	?	none	none	none	?	none	none	?	none	none	none	none	?	none	none	?	none	none	none	?	none	none	none	none	feebly	feebly
Gram	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.	neg.
Morphology	apparent bipolarity	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	as in last	uniform bacilli?	uniform bacilli?

A = acid production. G = gas production. A+G = acid and gas production. O = no reaction. ? = doubtful reaction. C = clot production. Reaction in rabbits refers to appearances found after injecting them intravenously with a large dose and as described in text.

Numbers refer to number of case from which the culture was obtained. Tubes incubated 48 hours at 37° C.

grew much more rapidly than those of the original culture. Again, while the original culture was non-motile, the virulent one had now become motile. It may be stated further that in cases of chicken cholera occurring naturally, I have found all varieties between that usually described in the text-books as typical (where none of the sugars are altered, no growth occurs on potato, the organism is non-motile, a very slender grower, and produces no indol), and the variety where almost every sugar is fermented with acid and gas production, &c., &c. Intermediate between these are placed organisms from a similar source which ferment a smaller or larger number of sugars with acid production only, others which ferment some with acid production, and others with acid and gas, &c., &c.

I have found this last state of affairs also in connection with the *B. bipolaris septicus ovium* (see Table I.).

If this table is examined it will be seen that very few of the organisms resemble one another. Five groups may, however, be formed from organisms which have the same reactions, as follows:—

Group I.

1. 20, lamb; grass sickness; lung pure.
2. 13, ewe; louping-ill; lung pure.

Group II.

1. 44, lamb; white scour; intestine pure.
2. 5, lamb; grass sickness; lung pure.
3. 16, lamb; white scour; lung pure.

Group III.

1. 1, lamb; white scour; intestine pure.
2. 31, lamb; white scour; intestine pure.

Group IV.

1. 48, ewe; louping-ill; intestine pure.
2. 25, lamb; white scour; intestine pure.
3. 60B, ewe; louping-ill; lung (along with 60A).

Group V.

1. 32, lamb; white scour; lung pure.
2. 11, lamb; white scour; intestine pure.

All the other 13 cultures are different from these and from one

another. None of the cultures isolated are identical with the *Bacillus Coli* isolated from human fæces.

The question arises as to how we can be sure in such circumstances that we are dealing with the same organism, and especially how it is possible to differentiate the more virulent and more biologically active form from members of the *B. Coli* group. This is a very difficult problem, but the following considerations help.

1. The post-mortem appearances of the animal from which the organism was obtained in pure culture from the heart-blood or lungs. In this connection, the effusion into the pericardial sac, the hæmorrhages into the heart muscle, the inflammation of and hæmorrhages into the mucosa of the fourth stomach, and the hæmorrhages and congestion of the kidney, should be particularly noted.

2. The typical bipolar staining, or what is better described as the ring or girdle shape of this bacillus, especially when films are made from the heart-blood or peritoneal cavity of an animal injected in these situations with the bacillus. Too much has been made, it would seem, in certain schools of bacteriology of the power to identify this organism by means of the morphology alone. There is a tendency to include in this group any organism which shows bipolar staining without having regard to its biological or pathological activities. A consideration of the great pleomorphism (in form) of which this group is admittedly capable on the one hand, and of the great variation in biological activity on the other hand, which I have just indicated, leads us to the following positions. Many organisms may be rejected from this group, because owing to their pleomorphism they may not be in the bipolar form at the time of examination. Again, many organisms may be admitted to this group because of an *apparent* bipolarity. Further, where sugar tests are performed, organisms which are typically "girdle" formed may be rejected from this group because of what is conceived to be abnormal sugar reactions.

The term bipolar staining would appear to be unfortunate. With a little imagination one could almost think that any stained bacillus took up the stain more at the poles than at the centre. A better term, and one describing accurately the appearances seen in a typical member of this group, would be

"girdle" bacillus (a term already in use), indicating a distinct clear space in the centre surrounded by a thin ring, thicker at the two poles, of stainable material. So far as my experience goes, I have met as yet no organism with the appearance last described which could not justifiably be, from its pathological properties, included in this group.

3. The production in rabbits when injected intravenously with *large* doses—(emulsion of one 24 hours' agar culture)—of the typical appearances found in the natural disease. It should be noted that large doses must be used. In such animals there is produced the typical amber-coloured or blood-stained effusion into the pericardium, the hæmorrhages into the heart, and intense inflammation and hæmorrhages in the stomach, intestines, and vermiform appendix. With no organism of the *Coli* group which I have as yet tried (and I have tested a considerable number) have I found these lesions produced. It should be stated further that these changes are produced both with the avirulent type and with the virulent type.

In an intricate problem like this, agglutination, &c., reactions are of little use, for Dr Wang and I found in our experiments that, while the serum of animals injected with the original and virulent strains agglutinated their own strains respectively, cross agglutination took place only to a very limited degree.

The question raised here is interesting from another point of view. I have already stated the opinion that white diarrhœa or milk sickness in lambs may be caused by the *B. bipolaris sept. ovium.* I based that opinion on the finding of this organism present, but more especially on the post-mortem findings in the actual cases of the disease. Nocard (15), who has worked at the corresponding disease in calves, states that it is due to an organism of this group; while Jensen (16) gives it as his opinion that it is an enteritis with a bacteriæmia due to various kinds of *B. Coli.* The interesting point about Jensen's view is that he differentiates his causal *Coli* bacilli into eight groups according to their reactions on the following sugars, &c.: glucose, maltose, lactose, cane, sorbose, arabinose, xylose, rhamnose, dulcite, and adonite. Further, certain of the organisms isolated fermented glucose and lactose with acid formation but no gas formation. These organisms further differed from one another

in their growths on the ordinary media in their motility, in presence of flagella, in power to form indol, and in the capacity and method of acting on milk. Further, a serum prepared against one strain, while acting on that strain, acted feebly or not at all on others. Jensen also states that white diarrhœa in calves may be due to the *bacillus lactis cerogenes*. He also, under the name of Paracolibacillosis, describes a diarrhœa with bacteriæmia in calves due to organisms of the paratyphoid, Gærtner and Ærtryck group; and under the name of Metacolibacillosis, another similar diarrhœal disease in calves due to an organism of the nature of Morgan's organism from summer diarrhœa. The variability in these organisms, all adduced as the cause of white scour, is striking, and harmony seems possible only by viewing them in the light of the findings by Dr Wang and myself.

With regard to the mechanics of the production of the symptoms in true Louping-ill, it would appear that many of them are referable to a condition of profound heart weakness, or, to speak more generally, to an affection of the whole cardio-vascular system. Thus the exudates in the pericardium, pleural sacs, and abdomen, the œdemas of the lungs and subcutaneous tissues, more especially about the neck region and the scrotum in tups, and the sudden death so noticeable in the disease, along with easily produced fatigue on exertion, all point to a heart lesion, in all probability caused by a toxin. This toxin would appear also to be active on the smaller blood-vessels, causing hæmorrhages in various places, and small hæmorrhages in the brain and cord may account for some of the nervous symptoms observable. In two cases with such nervous symptoms I have found a subdural hæmorrhage in the cervical region. Some of the nervous symptoms are also almost certainly due to action of a toxin directly on the cell elements of the central nervous system.

The disease would appear to affect all ages of sheep from lambs upwards. In lambs, however, a considerable part of what is called Louping-ill is in reality due to some other causes (see pseudo Louping-ill later.) The younger ages, including lambs and hoggs of the *home-bred* stock on a farm, would, however, appear to be the most susceptible, and the severity or otherwise of the outbreak is usually judged of by observing in

what proportion the disease is occurring among the older ages. In particular, hoggs are very liable, especially those bought in to the place, or those bred on the place and returning to it in the spring after having been wintered on low-ground farms. Lambing ewes are liable in somewhat marked degree to the disease for a week subsequent to lambing. If they take it previous to lambing the lamb is born dead or useless usually, while it is stated that thereafter the ewe frequently recovers rapidly. What has been said refers to the *home-bred* stock, but in stock *bred on low-ground farms* and taken to a "Louping-ill" farm, especially during April and May, all ages die equally.

As regards the time of year at which the disease is prevalent, it is worst from the middle of April to the end of May. A large number of cases, however, occur in September and October, especially among bought-in rams. It should be mentioned that the disease occurs among these at a time of year and under circumstances when in the majority of cases there are no ticks. Odd cases occur all through the year, but the periods of maximum occurrence are as given. It should be noted that while the less fulminant varieties of the disease (the so-called true Louping-ill) occur most markedly in the spring months, and the fulminant variety—Braxy—most markedly in the autumn months, cases of both varieties of the disease occur at both times.

The statements regarding the *condition* of the sheep attacked by Louping-ill are very vague. Some say that condition has nothing to do with it, while others state that it is the lean ones and those which have come poorly through the winter that are most liable. For their contention the last-named adduce as evidence their opinion that overstocking causes it, and that it is always worst in cold, dry, barren springs when there is no growth of grass. In connection with the latter view it has to be borne in mind that a great many of the sheep with Louping-ill are noticed to be suffering from it only when they have been ill for some considerable time and becoming leaner all the time, and it is just possible that this leanness, which in reality has been caused by the disease, has been assumed by some to be indirectly causal of the disease. Again, in regard to the cold barren weather preventing the growth of grass, and thus indirectly fostering the disease by causing

leanness of the sheep, it has to be remembered that not only does the cold, dry, barren weather (with its east wind, burning sun during the day and hard frost at night) act on the grass, but it acts also directly on the sheep by subjecting it to extremes of temperature within a very short time. It would appear, therefore, in default of further evidence, that lean sheep are not specially liable, and that all conditions of sheep take it, fat and thriving ones as well as those in more moderate condition. It is not denied, rather it is to be presumed that anything, such as deficiency of food, &c., which brings down the condition of the sheep, will lower its vitality and render it more liable to disease. It is a case here, however, of putting more important causes before less important ones.

In contradistinction to this, Braxy (which is here regarded as the fulminant variety of Louping-ill) attacks by preference the most thriving. This it does at a time of year when there is a possibility of the greedy thriving animal eating ravenously large quantities of frosted succulent material. This, a very sudden and acutely injurious thing, causes an acute and fulminant disease—Braxy. At no other time of the year can even a thriving hungry animal do injury to himself in this way nearly to the same extent. In the spring months when Louping-ill is occurring there is frost indeed, and cold east winds, but there is no succulent herbage. The same thing virtually applies to bought-in tups in September. They are in high condition, are box-fed usually, and care is taken that they do not get access to the conditions that cause Braxy. Nevertheless they take Louping-ill, a slower and less acute disease in most cases. They have, however, been usually brought from low-ground arable farms, where they have been pampered, house-fed, &c., to give them a showy appearance in the sale ring; have been more or less irregularly fed during the time of the sale; subsequent to this have usually travelled a long distance in a train, and then been turned out into a bare unsheltered field on some upland farm.

Such points as these lead us to a consideration of the chief determining cause of true Louping-ill. And to come to the point at once, every shepherd and farmer who has had experience of the disease and whom I have asked, has unhesitatingly stated that, with regard to the cases which occur in

April and May, cold, dry, barren weather with an east wind, hot burning sun during the day and hard frosts at night, is the chief determining cause; and with regard to the cases occurring in the autumn, the sudden change, climatic and otherwise, in the surroundings of the tups is responsible. To sum up, therefore, while Braxy is the result of a sudden violent chill, Louping-ill is due to a less violent one. Not only is this the opinion universal among shepherds, but the following instance occurring on a low-ground farm, where there were no disturbing features such as ticks, quality of food, nature of soil, &c., sometimes adduced as causes of Louping-ill, would seem to put it beyond doubt. On a low-country arable farm, situated in one of the most fertile and most intensively cultivated parts of Scotland, a flock of pedigreed sheep of one of the larger varieties was kept. They began to lamb in January, and when they were lambing they were kept in a field surrounded by a high wall situated on the lowest part of the farm near sea-level. In this field was a large shed, enclosed at the sides, but with open doors, to which the sheep could retire at any time. As a matter of fact, they always went into the shed during the night or when they were lambing. As more and more ewes lambed the space became cramped, and in order to make room for newly lambed ewes, those earlier lambed were shifted in batches to a field of young grass adjacent, and on the same level. This field, however, had no protecting wall and no shed. In March, immediately prior to a week of heavy snowstorm, a large number of ewes and lambs which had gradually collected from the first field into the second, were, in order to make room for more coming from the first into the second, transferred to a field of young grass situated at the top of a hill about 200 feet above their original position, exposed to the east wind, and entirely unsheltered. The heavy snowstorm came on from the east shortly after, several of them being buried in a snowdrift, and within a short time after this typical Louping-ill broke out. About twenty of them were taken with the disease in a marked form. They showed lameness in the legs and sometimes became so weak on them that the wind blew them over, and large numbers of them "went down." Of the twenty, two died, one of them two days after the illness began, and it was noticed that the carcase

in this case was jaundiced; the other showed head symptoms, wandering about aimlessly, biting savagely at a stone wall and also at grass—in fact the shepherd described it as mad. The day after it developed these symptoms it died, and the shepherd stated that he found "something" wrong with the heart. The other eighteen were removed to the low ground, and after having lain for a long time and having been lifted from place to place in order to allow them to eat grass, gradually got on to their feet again. Two months after the first onset many of them, however, were still showing signs of the disease in the form of slight lameness, unhealthy coat, absence of belly, &c. One in particular was still far from better. It could hardly walk, doing so with very short steps. The least thing knocked it over, and it could only eat grass when it was lying down.

No post-mortem material was obtained from these cases, but there can be no doubt that the cases were true Louping-ill, or, as it is more frequently called in the low country, "Stomach Staggers," and the determining cause in this case undoubtedly was the sudden exposure to more severe climatic conditions than those to which they had been accustomed.

The following reply from a farmer, on an entirely arable farm without ticks, relative to Louping-ill or Trembling, may be further quoted in this connection:—

"It (Louping-ill) generally takes place on this farm in the back-end after the first of October in my hoggets. I may here state that this farm is 650 feet above sea-level, and very much exposed, which has something to do with the disease. It generally attacks the ewe hoggets, and I consider that when the ewe hoggets are in raid it takes place then if you happen to give them a quick turn round with the dog. On such occasions I have seen them jump in the air and several times fall down dead. Others after getting a quick turn as above, jump up as before, fall on their side, foam at the mouth, and are quite rigid. Others again gnash with their teeth, foam at the mouth, and all four legs are in motion as if they were in a fit. I have seen lambing ewes affected in the spring similarly, but very few, and only one death in all my experience. There are no ticks on the farm."

The symptoms here described are those of the classical Louping-ill, and it should be further noted that these cases are

occurring among a class of sheep—hoggs—among which and at a time of year when Braxy is held to be the usual cause of death among sheep.

As regards the distribution of the disease, the only record, apart from the distribution mentioned in the Highland Society's Report (8), occurs in the Louping-ill and Braxy Committee's Report. If the maps given there of maximum distribution of the two diseases, Braxy and Louping-ill, be compared with one another from a broad standpoint, and with consideration of the difficulties incidental to framing such maps, due, amongst other things, to the inexactitude of the nomenclature of the diseases, it will be found that they can practically be superimposed. This in itself is a very suggestive fact with regard to the relation of the two diseases. Several correspondents, however, have denied the possibility of such a relation, because they state that they have seen plenty of farms with a great deal of Braxy and no Louping-ill. The answer to this objection can be found in consideration of the fact that while the *primary* cause of the two diseases is held to be the same—namely, the *Bacillus bipolaris septicus ovium*—the *secondary* causes of the two diseases are considered to be different. In Braxy the secondary cause is the eating of frosted succulent food, while in Louping-ill the secondary causes are extreme variations of outside temperature, possibly coupled in some cases with a weak resistance due to a diminished and poorer food supply. In other words, while they are bacteriologically considered to be the same, epidemiologically they are considered to be different.

The question arises as to whether the disease is contagious or not. It cannot be inferred that because a large number of the members of a flock are affected with the disease at or about the same time, that the disease is contagious from one to another. The circumstances are capable of explanation in quite another way, namely, that a widespread determining or secondary cause is acting on all the members of the flock at the same time. This would indeed appear to be the case in the main in connection with true Louping-ill. Here the widespread determining cause is the prevalence of dry, east-windy, barren weather, with hot sun during the day and hard frost at night. But to a limited extent the disease would appear to be also contagious, for it is universally believed by shepherds that

if a ewe with a lamb sucking her takes the disease, the lamb invariably takes it also, even although it is removed immediately from its mother. In many cases, undoubtedly, this opinion may have been arrived at by observations on what were really Pseudo Louping-ill cases, but that such contagion does occur in true Louping-ill is undoubted. I myself have seen such a case, where I had the opportunity of examining post mortem both mother and lamb.

If the lamb has been removed before it has sucked the infected mother, there would appear to be much less danger; and again, if one of twins takes the disease, the other would appear not to be liable to take it unless the mother has it. The infection in this case possibly comes from the fæces of the mother, and here takes place only by very close association. Sometimes a ewe with the disease in a mild form has a fair milk supply, and her lamb having died, a series of as far as three fresh lambs, when lambs are plentiful, may be "set on" to her, each, however, dying in turn.

Owing to the wide ranging of sheep on hill pastures, contagion cannot be a common method of spreading the disease among the flock. It has to be noted, too, that in the case of contagious infection just mentioned, the infected animal is a young one, with presumably, as yet, very little power of resistance, especially in its alimentary tract. In this connection it should be noted that the disease, in very young lambs, takes the form of diarrhœa, as has been already mentioned.

Suggestions for Prevention.

Taking into consideration the nature of the secondary causes of true Louping-ill, many of the suggestions to be given may savour of counsels of perfection, impossible of being carried out under existing circumstances. As regards the subjection to great variations in temperature, something could possibly be done on hill farms to mitigate this in the way of shelter-belts. On low-ground farms where sheep are more under control, sudden exposures to conditions of great cold should be avoided. I can suggest nothing further in the way of a practicable method for combating this, the chief secondary cause of the disease.

With regard to other circumstances which have a bearing on the disease, or have been found often in association with it, some benefit may be derived from discussing them. Overstocking, adduced as a cause by some, on general principles should be avoided. Where it is carried on it certainly will tend to make the sheep leaner in the spring and of less resistant power to injurious outside influences. Again, on general principles, lean and ill-thriving lambing ewes could be separated about February from the general flock for special feeding, possibly on cultivated land with young grass, where this is available. A supply of young grass on cultivated land would appear to be very beneficial to the sheep even when the disease is actually occurring in the flock. The hill should be burnt as widely and as regularly as possible. This does away with the bent and dry grass, and encourages the growth of fresh young shoots. The keeping of the rough grass down by pasturing with cattle in the summer time is considered by many to be very beneficial. In this case, a very fine line has to be drawn between keeping enough cattle to do the work efficiently and reducing the sheep stock in accordance with the number of cattle added. Otherwise in one case the grass is not kept clean and bare, and in the other, there is virtual overstocking. Rock-salt is lauded by some as a specific preventive of Louping-ill; by others, this special benefit has not been observed. Its use, however, is justifiable on general grounds. Draining of the land is beneficial on general grounds, and, provided that the land is not made too dry, according to some, is helpful in diminishing Louping-ill. Lime applied to the hill would be beneficial if this were economically a possibility. The practice of udder-locking of grit ewes, unless very gently done, would appear to be prejudicial, not so much due to the loss of wool but from possible rough handling. It is not, however, suggested that udder-locking, even when roughly done, causes Louping-ill. It will be very harmful, however, to any that may have the disease in a slight form. Similarly hounding with dogs should be avoided at this time, not so much from the point of view that such hounding causes the disease, but that an animal with the disease on it may be killed by the sudden fright and strain put on the heart. It is hardly likely that a perfectly healthy animal would tumble over dead

in such circumstances, and the absence of such cases at other times of the year supports this view.

With regard to wintered-away hoggs and sheep being brought on to the farm, this should, as far as possible, be carried out outside the Louping-ill season. This is not always practicable. Many farmers, however, manage to keep them away till the middle of June, and then bring them by slow gradation up to their farms. Fresh stock bought in should, as far as possible, be from farms at a similar elevation, or even (some would also say better) from a farm affected with Louping-ill. When the disease breaks out among the hoggs on the hill, they should be brought down, sick and healthy, to the "in-by" fields. Some recommend that, on a Louping-ill farm, the hoggs should never be wintered away. Here, of course, the question of loss from Braxy has to be considered in giving effect to such a recommendation.

With regard to the disease in rams, some *via media* can surely be found between the tup-seller's point of view and the tup-buyer's in regard to the methods in vogue for preparing tups for sale. Failing this, some method of gradual acclimatisation to the new surroundings will have to be found, and the time is short between the ram sales and the time for going out to the ewes for this to be done very gradually. Some have solved the problem by arranging for the rams being kept on the low-ground farms where they were bred till it is time to put them out to the ewes. Their loss then is not so great, because if the sheep dies then, they have at least had the use of him, and many of those brought home earlier and affected with Louping-ill, even though they do not die, are quite useless that season.

In my article on Braxy, I mentioned that owing to the nature of the case, and to the results already obtained in this direction, the dealing with the primary cause and the use of a vaccine prepared from the causal organism could not, at the present stage, be recommended. The case, however, is somewhat different with regard to Louping-ill. It is usually a more chronic disease, and both for prevention, especially in the case of hoggs returning from wintering, and for treatment in the chronic cases, a trial would be justifiable. Up to the present I have not had the opportunity. In the case of returning

hoggs the circumstances would appear to be ideal for a thorough test of such a prophylactic. They could be inoculated several times, if necessary, on their wintering ground, and the result observed when they returned home.

As regards treatment of cases when they actually occur, mild cases would appear to have been greatly benefited by the administration of a purgative such as salts, treacle, &c. The animal should be kept as quiet as possible. It should be removed to a sheltered place, preferably on the low ground and on young grass, if this can be accomplished without disturbing it too much. If there is danger of this, some sort of shelter should be built for it on the spot. The animal should be left alone, and not disturbed any more than is consistent with good treatment. These remarks apply equally to all types of the disease. Bleeding from the tail or eye vein has been used by some in such cases, and in the heart-failure type with beneficial result.

In the type of case where sudden heart failure is evidenced by tiredness on slight exertion, laboured breathing, staggering, and collapse, some stimulant is indicated. Many use whisky. This is to be recommended especially for a crisis, but the use of a more lasting and more definite heart tonic, such as digitalis or strophanthus, would appear to be indicated.

In the cases of actual fits and violent nervous symptoms, some give potassium bromide and chloral. This is at best symptomatic treatment, but it may help to tide over a crisis. In the chronic cases, where the animal is "down," the ultimate recovery in greater or less measure should not be despaired of. The animal should be put on to young grass, and carefully lifted from place to place, so that it is removed on to a clean spot, away from the fæces and urine which have collected. It is thus also enabled to feed on fresh grass. Additional food may be given in the way of gruel and cow's milk. The young grass, gruel, and milk thus supply it with water, and tend to counteract the dried condition of the contents of the first stomach and the excessive constipation which is observable in these cases. The question of treating such a case with increasing small doses of strychnine should also be considered; and, as mentioned above, there is an opportunity here for the trial of vaccines as a curative measure.

Pseudo Louping-ill.

The statement has been made in books and elsewhere that the grass tick, common on sheep in upland pastures, is the cause of Louping-ill. With regard to such statements I have already brought forward evidence that true Louping-ill can occur and does occur where ticks do not exist. Apart from this, however, the statement made by shepherds, farmers, &c., who have had experience of the disease, some of them lifelong, is not that the tick is the cause of the disease, for this they do not believe, but that where the tick is, Louping-ill is always worse. This is exactly the attitude towards this subject which is taken up in this paper, only an attempt has been made here to define exactly what is meant by Louping-ill. What has been called the true Louping-ill has been separated off, and has already been fully discussed. In no sense can it be said to have any relation whatever to the tick. It occurs at places where there are no ticks, and at times of the year when ticks are hibernating. By no means, however, is the intention here to minimise the injurious effect that ticks have on sheep stock on upland farms. For they have a decidedly injurious influence, especially on lambs. The bulk of the diseases in lambs on upland farms confounded with true Louping-ill, and which may be called Pseudo Louping-ill, are due to ticks. By the production of infected and painful sores at the point bitten, and by the swelling of the lymphatic glands in association, they produce lameness; by pyæmia spread through the body from the original site they can produce abscesses in almost every organ of the body, especially in the heart, lungs, kidneys, and liver, as also in the joints of the limbs and of the spinal vertebræ. Thus death with various symptoms, lameness, paralysis, and deformities of various kinds, is produced. The organisms present in the primary and secondary metastatic abscesses are in my experience usually a variety of staphylococcus.

The existence of ticks is limited by several known circumstances. In the first place, they are present only when they have been introduced by some means or other to any given piece of land. In the second place, certain conditions are necessary before they can have a continued existence when introduced. Thus the cultivation of land as it is carried out on

arable farms, and the absence of permanent pasture, prevents their continued existence even if introduced on such places. Again, altitude is unfavourable to their continued development. Thus the farms at high waterheads and the higher parts of farms lower down the valley, provided the sheep are restricted to these parts and do not range right down to the water-side, are much freer from ticks than farms lower down the valley and the parts of such farms abutting on the stream at the bottom of the valley. It is a common saying among shepherds that the farms at the waterheads and the high hirsels on the lower farms are much freer from Louping-ill than the farms lower down the valley and the low hirsels near the water-edge. The explanation of this may be that as regards true Louping-ill the sheep on the higher ranges are hardier and can endure climatic variations much better. Point is given to this by the fact that home-wintered hoggs on an upland farm take Louping-ill far less severely than their low-ground wintered-away flockmates (exactly similar to them in every other respect) when they return in the spring. Climatic conditions, therefore, sufficient to cause true Louping-ill among sheep down the valley, have very little power, it would seem, to cause it among the hardier sheep at the waterheads. On the other hand, as regards Pseudo Louping-ill, the practical absence of ticks at the waterheads would explain the practical absence of this disease there.

Apart from causation of actual recognisable disease and death among lambs, the irritation caused by the presence of ticks, especially when in large numbers, must be detrimental to the health of the young animal and interfere with its thriving.

Other forms of Pseudo Louping-ill can be treated very briefly. Navel-ill, with subsequent joint affections, is rare on most hill farms where the ewes are lambed out in the open. If, however, they are lambed in an enclosed place, more especially in fixed lambing pens, its occurrence is quite frequent. The ground in such places is usually very dirty, and infection is rendered very liable, owing to the manure and decomposing after-births usually to be found in such places. Here a special variety of Pseudo Louping-ill may be touched on. It is a matter of common observation among shepherds

that when a ewe on lambing, owing to a deficiency of milk, is brought into an enclosure, and the lamb fed *partly* on cow's milk and partly on what it can suck from its mother, such a lamb never turns out a success. It may develop navel- and joint-ill, possibly from being in the (dirty) enclosure; on the other hand, when it is sent to the hill it almost always "does no good." Possibly this may in some cases be due to its having now to depend entirely on its mother's milk, which, never abundant, is now more scanty when she has to feed herself on the bare pasture on the hill. On the other hand, a "pet" lamb brought up *entirely* on cow's milk would appear not to be liable to be affected in this way.

Wool-ball in the stomach is cited by many shepherds as a cause of death in lambs. It occurs more in the shaggy breeds, and is due to the lamb, in an endeavour to fasten on to the teat, getting hold of loose wool, and, being unable to get it out of its mouth, swallowing it. With regard to this question, it may safely be said that if any lamb whatsoever, of a week old, were killed, and its stomach examined, some wool would be found in it. Even large wool-balls may be present without appearing to cause any trouble; the only cases where it can definitely be presumed that wool-ball is the cause of death are those where the wool-ball firmly plugs the pylorus, or where it entirely fills up the stomach, of both of which varieties I have seen a single case.

Prevention and Treatment of Pseudo Louping-ill.

As regards the possible means of prevention and cure of Pseudo Louping-ill, each variety has to be treated according to its cause. Thus the variety caused by ticks can be prevented by the extermination of the tick. Even from the point of view of damage done to sheep stock by the irritation, &c., of tick bites, short of actual disease, there is a sufficient reason for an attempt being made to do this, and do it thoroughly. How this can or may be done does not fall to be considered here.

As regards the prevention and treatment of other varieties of Pseudo Louping-ill, the only one which deserves further mention here is navel-ill. This does not occur much in hill stock, where the ewes are lambed on the open and unenclosed

space. Where, however, fixed lambing-sheds exist, it sometimes causes great loss. Fixed lambing-pens should, as far as possible, be done away with, and temporary erections of hurdles and straw be erected. These should be put on a different piece of ground every year. As a further measure of prevention, tincture of iodine and tar may be applied to the navel immediately on birth. These latter recommendations are impracticable for general hill stock, and are only suitable for high-class sheep on hill places, or for stock on low-ground farms.

Treatment of these two varieties of Pseudo Louping-ill just mentioned, once they have occurred, would appear to be mainly surgical, namely, the opening of the abscesses. In a great many cases this is difficult or dangerous, and it is a question whether it is worth while. If the abscess or swelling is in a joint, the animal is almost certain to be deformed, and opening the abscess, while it does not remove the likelihood of this deformity, adds the risk of mixed infection and death of the animal.

SUMMARY.

Louping-ill or Trembling, according to the view propounded here, is divisible into two groups—true Louping-ill and Pseudo Louping-ill. True Louping-ill (which includes "Staggers" or "Stomach Staggers" of hill farms and arable farms) is divisible into several varieties, as mentioned in the text. Specially, according to the view expressed here, does it include Braxy or sickness and "grass sickness," which are held to be the very acute forms of the disease. The disease "milk sickness" in lambs is considered also to be a variety of this same disease for reasons given in the body of the article.

These diseases are considered to be essentially of the same nature, in that they are held to be caused by the same organism—the *Bacillus bipolaris septicus ovium*. Epidemiologically they are considered to be different, in that while Braxy is usually produced by eating rapidly large quantities of succulent material covered with hoar-frost, true Louping-ill in most of its varieties is considered to be caused chiefly by exposure to extreme degrees of temperature within a short interval. "Milk sickness" is considered to be in a restricted

degree caused by contagion. The grass tick is held to be responsible for the production of the bulk of the cases of Pseudo Louping-ill. Navel-ill, with its attendant joint-ill, contributes some cases, while aggravated wool-ball, injuries, &c., add a few to the sum total included in this term. A discussion on possible means of prevention and treatment is embodied in the text.

In the preparation of this report a circular of questions relating to Louping-ill (see Appendix) was distributed. To the gentlemen who replied I wish here to express my indebtedness. I also wish to record my thanks, for help generously given, to Mr Carruth and Mr Macpherson, of the Edinburgh and East of Scotland Agricultural College; to Mr Barber, of the Board of Agriculture for Scotland; to Mr M'Callum, of the Edinburgh and East of Scotland Agricultural College; and to Professor James Ritchie.

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APPENDIX.

Copy of Schedule of Questions distributed to Farmers, &c., in connection with this Inquiry into Louping-ill.

A.—*For Hill Farmers and Hill Shepherds especially.*

1. In the light of your experience, please criticise the enclosed statement regarding the disease, and especially with regard to the three varieties of the disease.

(A short account was given on a separate slip of the symptoms, &c., of Louping-ill.)

2. Have you observed paralysis occurring among tups bought in at the back-end, and which were said to have Louping-ill or Trembling?

3. What are your views with regard to the "condition" of the sheep when it is first attacked with Louping-ill or Trembling?

One authority states "that it is usually the fattest of the flock that are cut off by it."

4. (*a*) Does the disease occur in your experience mostly among sheep from birth to one and a half years of age?
   (*b*) Are hoggs specially liable?
5. Have you noticed—
   (*a*) when an animal was in the acute state (Stage I. above) of the disease, that it was running at the eyes and nose?
   (*b*) that while an animal might be very ill of Stage I., the disease would not progress further, and the animal would recover?
   (*c*) that true cases of the disease might occur, which did not even get the length of a bad attack of Stage I.
6. Have you ticks on your sheep?
7. Do you consider that ticks are the cause of Louping-ill or Trembling? Give reasons for your answer.
8. Have you ever seen, or do you know of, cases where—
   (*a*) ticks occur on sheep, without there being any Louping-ill or Trembling?
   (*b*) Louping-ill or Trembling occur, without there being any ticks?

(The tick should be carefully distinguished from the ked, which is quite a different insect.)

9. (*a*) Have you ever seen cases of Louping-ill or Trembling occurring in animals other than the sheep?
   (*b*) What animals were they?
   (*c*) What were the symptoms?
10. What direction does the ground face, which in your experience is most liable to Louping-ill or Trembling?
11. What kind of weather in your experience predisposes to Louping-ill or Trembling?
12. What is the state of growth of grass when Louping-ill or Trembling is prevalent?

13. What effect have the following procedures in your experience on the occurrence of Louping-ill or Trembling?—

(*a*) draining of the land.
(*b*) keeping down rough pasture by means of cattle.
(*c*) application of lime to the land.
(*d*) providing rock-salt for the sheep to lick.
(*e*) over-stocking.
(*f*) udder-locking.

14. Do you consider that Louping-ill or Trembling could be prevented in the case of hoggs by more careful attention being bestowed on them when they return from wintering, for example, by protecting them from exposure to the cold, which must necessarily be greater in the uplands than on the low-ground farms where they have been during the winter?

15. Do you consider Louping-ill or Trembling to be infectious?

16. What are your views regarding the following statement from an old writer on the subject of Louping-ill or Trembling?

"This disease arises often from the Braxy, and is generally a favourable symptom. It is never severe, however, when it is a consequence of Braxy, and the stiff neck never accompanies it."

17. Do you think there is a relation between Braxy and Louping-ill or Trembling, in the sense that Braxy might be the very acute form of the disease, while Louping-ill may be the more chronic condition? (In this connection it should be noticed that it is stated that they occur at the same times of the year.)

Please give detailed reasons for your statements in answer to this question.

18. How soon after the return of the hoggs from their wintering ground does Louping-ill or Trembling appear amongst them?

19. Have you noticed any relation between Braxy and Louping-ill such as the following, that, if means were taken by which Braxy was much less in the back-end, more Louping-ill appeared the following spring?

20. Cases may die in a few hours from Louping-ill or Trembling. How would you distinguish such cases from cases of Braxy?

21. In old sheep, hoggs, &c., have you noticed the formation of abscesses in various places as the sheep was recovering from Louping-ill or Trembling? Where were the abscesses, if present?

22. If a ewe takes ill of Louping-ill or Trembling at the time of the birth of the lamb, how does the lamb fare as regards taking the disease, if

(*a*) it is allowed to be suckled by her?
(*b*) it is nursed by another and healthy ewe?

23. Have you noticed that while you have cases of Varieties I. and II. markedly at the beginning of the outbreak of the disease in a flock (say in beginning of April), Variety III. occurs much more towards the end (say middle or end of May)?

24. Do you think that the disease is more prevalent, or do you think the opposite is the case, on limestone farms?

25. (*a*) Do the animals take the disease a second time?
(*b*) If so, are they very liable to do so?
(*c*) Do they have it as bad?

26. Is any special breed of sheep more liable than another?

27. If one of twin lambs takes the disease, does the other take it as well?

28. Have you noticed any special outbreak of the disease subsequent to clipping?

29. Have you noticed any relation between amount of Louping-ill or Trembling and the date at which lambs were born?

30. Do you know of any method of value in—
(*a*) treating Louping-ill or Trembling cases?
(*b*) preventing the occurrence of the disease?

31. Have you noticed that lambs brought up on cow's milk were more liable to the disease?

32. Have you ever seen a case where a ewe suffering from Louping-ill or Trembling gave birth to a lamb suffering from it also at the time of birth?

33. Please give here any other information which you think may be of value in connection with this inquiry.

B.—*For those having to do with Sheep on Low-ground Arable Farms.*

1. After careful reading of the short description of Louping-ill or Trembling given, do you recollect having seen cases answering to that description among the sheep on your low-ground pasture? It is more than likely that you would not call them by the term Louping-ill or Trembling, or indeed give them any name. If you have seen such cases, would you describe fully the circumstances under which they occurred?

2. Have you any ticks on the sheep on your farm?

(The tick should be carefully distinguished from the ked, which is quite a different insect.)

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